Baseline Proposal for 100G Backplane Specification Using PAM-2

Mike Dudek QLogic

Mike Li Altera

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Supporters.

Peerouz Amleshi	Molex	Mounir Meghelli	IBM
Vittal Balasubramanian	FCI	Brian Misek	Avago
Stephen Bates	PMC Sierra	Jitendra Mohan	TI
Ahmet Balcioglu	Hittite	George Noh	Vitesse
Mark Bugg	Molex	Phil Northcott	PMC-Sierra
Frank Chang	Vitesse	David Ofelt	Juniper
Wheling Cheng	Juniper	Gourgen Oganessyan	Intersil
Kai Cui	Huawei	Tom Palkert	Luxtera
John Ewen	IBM	Pravin Patel	IBM
Freddy Fu	Huawei	Edward Priest	Juniper
Mark Gustlin	Xilinx	Rick Rabinovich	ALU
Ziad Hatab	Vitesse	Iain Robertson	TI
Xi Huang	Huawei	Song Sang	Semtech
Walter Katz	Si Soft	Oren Sela	Mellanox
Myles Kimmit	Emulex	Scott Sommers	Molex
Scott Kipp	Brocade	Francois Tremblay	Gennum
Martin Langhammer	Altera	Steve Trowbridge	ALU
Ryan Latchman	Mindspeed	Xiaofeng Wang	PMC-Sierra
Jeffery Maki	Juniper		

Introduction

- Backplane specs based on PAM-2 have been developed by a number of organizations.
  - IEEE 802.3ba has a 4 lane specification for a 4 lane backplane 40GBASE-KR4 operating at 10.3125GBd each lane. This uses the same electrical specifications as the single lane 10GBASE-KR specification
  - Fibre Channel FC-PI-5 has a specification for 16GFC operating at 14.025GBd for a backplane channel (Epsilon T to Epsilon R).
  - OIF has a specification CEI-25G-LR for backplanes operating in the range 19.9-25.8GBd over a channel with 25.5 dB loss at Nyquist
- These specifications have much in common. The basic methodology is the same, although there are some subtle differences in the details.
- This document is a proposal built on these specifications for 100GBASE-KR4 (4x25GBd).

Introduction (cont)

- All test methodologies refer to 802.3ba unless stated otherwise.
- This specification is based on a channel loss budget of 30 dB at a signaling rate of 25.78125 GBd to meet a BER of 1e-12
- Optional FEC is incorporated to reduce the BER and/or achieve higher losses of 35 dB. The proposal is not to change the Tx specifications for any change in signaling rate (time specifications will be kept the same in UI). The Channel will obviously have higher loss and the Rx will have to meet an uncorrected BER of TBD (approx 1e-6) with a more stringent channel with the worst case Tx.
- This proposal is not intended to compete with the test methodology ad-hoc being chaired by Charles Moore. The intent is to update this with the results from that group, when they have been agreed.

Tx proposal

- A 3 tap FIR filter is proposed. (Similar to 10GBASE-KR, CEI-25G-LR of OIF, and FC-PI-5 of FC)
  - OIF has determined that additional tap was not helpful
- Tx training using the same algorithm as 10GBASE-KR is proposed.
- Suggest to use the linear pulse fit methodology of 802.3ba subclause 85.8.3.3 to enable transmitter testing with a test board with some loss.
- Suggest that it may be better to provide min/max tap weights (as is done in CEI-25G-LR) rather than the precursor and postcursor fullscale range values.

Tx specification

Transmitter Characteristics at TP0				
Parameter	IEEE subclause reference	Value	Units	Comment
Nominal Signaling rate		25.78125	GBd	
Differential peak to peak output voltage (max)	72.7.1.4	1200	mV	same as KR and OIF
Differential peak to peak output voltage (max) with Tx disabled.	72.6.5	30	mV	same as KR
Common-mode voltage limits (max)	72.7.1.4	1.9	V	same as KR
Common-mode voltage limits (min)	72.7.1.4	0	V	same as KR
Differential output return loss (min)	72.7.1.5	TBD		
Common-mode output return loss (min)	72.7.1.6	TBD		
Common-mode AC output voltage (max, RMS)		12	mV	Same as OIF (ba was 30mV but includes a connector)
Transition time (20-80%) (min) de-emphasis off	72.7.1.7	8	ps	Same as OIF
Steady state output (Vf) (max) de-emphasis off	85.8.3.3	0.6	V	Same as OIF
Steady state output (Vf) (min) de-emphasis off	85.8.3.3	0.4	V	Same as OIF
Linear fit pulse (min) de-emphasis off	85.8.3.3	0.8*Vf	V	Same as OIF

Tx specification (cont)

Parameter	IEEE subclause reference	Value	Units	Comment
Transmitted waveform				
max normalized error (linear fit) "e"	85.8.3.3	0.037		same as 802.3ba
normalized coefficient step size (min)	85.8.3.3.2	0.0083		same as 802.3ba
normalized coefficient step size (max)	85.8.3.3.2	0.05		same as 802.3ba
minimum precursor fullscale range	85.8.3.3.3	1.54		same as 802.3ba
minimum postcursor fullscale range	85.8.3.3.3	4		same as 802.3ba
Far-end transmit output noise (max)				
Low insertion loss channel	85.8.3.2	2	mV	same as 802.3ba
High insertion loss channel.	85.8.3.2	1	mV	same as 802.3ba
Max output jitter (peak-to-peak)				
Random jitter	72.7.1.9	0.15	UI	same as 802.3ba and OIF
Duty Cycle Distortion	72.7.1.8	0.035	UI	same as 802.3ba and OIF
Total jitter excluding data dependent jitter.	83.5.10	0.28	UI	same as 802.3ba and OIF

Tx specification (cont)

These parameters are the same as OIF

. Linear fit pulse and equalizing filter parameters

Parameter	Value (UI)
Linear fit pulse length T_N_p	8
Linear fit pulse delay T_D_p	2
Equalizer length T_N_w	8
Equalizer delay T_D_w	2

Channel Specification

- The Channel specification is proposed to be informative and similar to 10GBASE-KR and CEI-25G-LR
- The insertion loss max will take the following general form

$$IL\max = \begin{cases} a_{0m} + a_{1m}\sqrt{\dfrac{f \times f_{\max}}{f_b}} + a_{2m}\dfrac{f \times f_{\max}}{f_b}, & f_{\min} < f < \dfrac{f_b}{2} \\ b_{0m} + b_{2m}\dfrac{f \times f_{\max}}{f_b}, & \dfrac{f_b}{2} \le f < f_b \end{cases}$$

- IL_{max} (f_b/2) is targeted at 30 dB w/o FEC and 35 dB with FEC
- f_{min} = 50 MHz, and rest of the parameters TBD

Channel Specification (continued)

- The insertion loss is fitted to the insertion loss equation using the OIF test methodology described in OIF document http://www.oiforum.com/public/documents/OIF_CEI_03.0.pdf section 12.2. The fitted insertion loss equation is listed below. Note that this test methodology fits the curve up to the signaling rate with the pass/fail limits for ILD and ILDrms to 0.75 signaling rate.

$$IL_{fitted}(f) = a_0 + a_1\sqrt{\frac{f}{f_b}} + a_2\frac{f}{f_b} + a_4\left(\frac{f}{f_b}\right)^2 \ (dB)$$

Channel Specification (cont)

- Propose to limit the values of the “a” coefficients to restrict the amount of square root and square terms which are more difficult to equalize.
- ILD: Propose to specify an ILD envelope.
- ILDrms: Propose to specify ILDrms (the rms deviation of ILD) as defined in OIF. This would potentially be included in a trade-off with crosstalk and noise and channel loss. It may also be replaced by a different measure of integrated ILD based on work from the test methodology group).
- Crosstalk and noise: Propose to have a Max ICN allowance which is a function of loss at Nyquist. Loss to extend to 30dB for low ICN (and low ILDrms)

Channel Specification (cont)

- The differential return loss, differential to common mode return loss, and common mode return loss would also be specified, as well as the differential to common mode through response.

Rx specification

- The Rx is specified to meet the required BER when specific stressed input signals (including jitter, noise and insertion loss versus frequency) are applied.
- These input signals are generated by passing a degraded signal from a pattern generator through a maximum loss channel and a lower loss channel with more noise degradation. Also an even higher loss channel with the use of FEC
- Differential return loss, common mode return loss, and differential to common mode conversion would also be specified.

Conclusions

- A specification is proposed for a PAM-2 backplane system achieving 30 dB loss at Nyquist without FEC and 35dB loss at Nyquist with FEC.
- Proposal is to adopt this as the baseline proposal for meeting the backplane objective in 802.3bj.

Backup

Thoughts on a 2 Phy solution. Not discussed with all supporters.

- Adopting 2 phys will require phy vendors to design two different phys.
- The two Phys will potentially require extra silicon (cost) to support both phys in many chips.
- Having two phys for similar applications has historically been a poor choice.
  - 100Base-T4 was an alternate Phy to 100Base-T operating over existing Cat 3 cable with higher complexity instead of using the newer medium (Cat 5 cable). It was not a success.
  - 10GBASE-LRM was an alternate Phy to 10GBASE-SR operating over existing OM1 and OM2 with higher complexity instead of over the newer medium (OM3). It has not been a success.